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A European morpho-functional classification of humus forms

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ABSTRACT

In Europe an abundance of humus taxonomies exists starting with early approaches in the late 19th century. Frequently used in an international context, they do not cover all site conditions in the European area. Although having basic concepts and general lines, the European (and North American, Canadian) classification systems differ in important parameters used for the description and classification of humus forms. These discrepancies result in incongruities, so they require adjustments when exchanging partially compatible soil data, even between nearby countries. In 2003, 26 European specialists in humus forms met in Trento (Italy) and decided to formulate rules of classification based on morphogenetic descriptions and diagnostic horizons, adapted to European ecological conditions. Taking into account old and new European and North American systems of humus forms classification, six main references (Anmoor, Mull, Moder, Mor, Amphi and Tangel) were defined, each of them further divided into more detailed categories. This inventory assigned a strong discriminatory power to the action of soil animals. Both semiterrestrial (anoxic) and terrestrial (aerated) topsoils were classified. Descriptors of diagnostic horizons were conceived in accordance with recent international soil classifications. Assigning an 'ecological value' to each main humus form along a gradient from biologically active forms, degrading and incorporating all organic remains, to those characterized by the accumulation of poorly transformed organic matter, this European system of classification avoids a strong hierarchical structure and allows a flexible approach open to additional ecological contributions and renditions.

1. Introduction

1.1. Basic concepts

The humus form is the part of the topsoil that is strongly influenced by organic matter and coincides with the sequence of organic and underlying organo-mineral horizons. During the 19th century, scientists noticed that the type and rate of decomposition of these organic components, as well as the incorporation of organic matter (OM) in mineral horizons, vary according to forest type (review in Jabiol et al., 2005). These observations led Müller (1879, 1884, 1887, 1889) to define three 'humus forms', named Muld (later becoming Mull), Mor and Mullartiger Torf (now Moder), characterized by their climatic, geological and biological conditions of formation in Danish beech forests. From the outset it was evident to Müller that the humus form corresponds to the "expression of life" within the topsoil. Many authors contributed to the development of a classification system of humus forms based on the key role of living components in the topsoil. The most prominent contributions are those of Babel (1971), Delecour (1983), Hartmann (1944); Hesselmann (1926) and Kubiëna (1953).

All these concepts still form the basis of modern classifications of humus forms (AFES, 1995; 2009; Baize and Girard, 1998; Baritz, 2003; Brunner et al., 2002; Green et al., 1993; Humusformen, 2004; Jabiol et al., 2007; Jabiol et al., 2009; Nestroy et al., 2000; Van Delft et al., 2007; Zanella et al., 2001, 2006). Although Canadian (British Columbian) and French classification systems are frequently used in an international context, none of them covers site and climate conditions worldwide, not even all European forest ecosystems. Moreover, the

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new national classification systems differ according to the parameters used for describing and classifying humus forms as well as for scaling diagnostic parameters (Baritz, 2003; Schoeneberger et al., 2002). Similar designations of humus forms often have different contents.

1.2. Harmonization purposes

With harmonization purposes in mind, a wide range of European specialists met in Trento (Italy) in 2003 and formed a European Humus Group with the aim of improving the compatibility of established national systems of classification and setting out a unified European reference for humus forms. The present synthesis was elaborated during the course of four plenary field sessions held in Alpine (Trento 2003, Vienna 2004, San Vito di Cadore 2005) and Mediterranean (Cagliari 2007) ecosystems. In these workshops, the place of lesser known Terrestrial humus forms such as Tangel and Amphi and that of semi-terrestrial humus forms was discussed and included in a new classification (Jabiol et al., 2004; Zanella et al., 2009). In the meantime the key of humus forms was also tested by non-specialists in order to improve it and to discard interpretative drawbacks. In the future, the proposed humus form classification will also be included in a worldwide topsoil characterization that is currently being prepared (Broll et al., 2006).

This paper focuses on the aims and principles of the proposed European classification, details and keys being found in a more complete review available at: http://hal.archives-ouvertes.fr/docs/00/56/17/95/PDF/Humus_Forms_ERB_31_01_2011.pdf.

2. Morpho-functional bases and references for the classification

At the end of the first meeting of the Humus group (Trento, Italy, 2003), after numerous field tests and discussions, the members of the group agreed on a very important "principle of classification": the classification process has to take into consideration only references (objects observable in the field or complexes of objects) which show an evident "morpho-functional" shape or core. This means that: a) each reference must be recognizable thanks to its particular and characteristic morphology; b) this morphology must be easily detectable to the naked eye or with a 5–10× magnifying hand lens; c) the function of the reference within the soil system has to be well expressed, identifiable or reasonably assumed to be possible.

The references of the classification are arranged in a nested way: basilar components (from intact leaves/needles until more or less degraded remains, animal droppings, roots, mineral particles…) are arranged in diagnostic horizons (discernable supra-structures of basilar components), themselves arranged in humus forms (evident well structured sets of diagnostic horizons). The detection in the field of the basilar components allows the identification of the diagnostic horizons, and the order and thickness of these horizons in the topsoil allow the humus forms to be classified. The basilar components are presented below, while the diagnostic horizons and humus forms are described in Sections 3 and 4.

2.1. Recognizable remains vs. humic component

Fresh litter is generally made up of 100% **recognizable remains**. They correspond to leaves, needles, roots, bark, twig and wood pieces, fragmented or not, whose original organs are recognizable to the naked eye or with a 5–10× magnifying hand lens. Depending on local climatic and biological conditions, this organic material will be rapidly or slowly transformed into **humic component** as a consequence of biological activity in the site (Fig. 1a). The **humic component** is formed by small and non-recognizable organic remains and/or grains of organic or organo-mineral matter, mostly comprised of animal droppings of different sizes. The original plant/animal organs which form the litter and generate smaller particles (free or incorporated in animal droppings) are not recognizable to the naked eye or with a 5–10× magnifying hand lens.

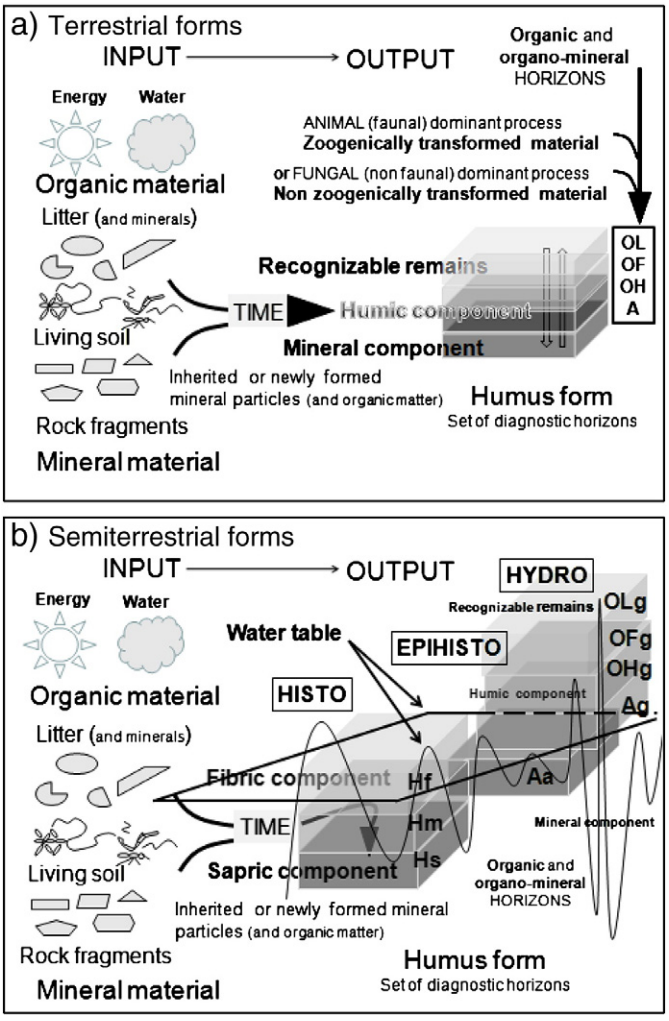

Fig. 1. Vocabulary and dynamic formation of an example topsoil in a) Terrestrial and b) Semiterrestrial conditions. Above- and below-ground processes are similar. On one side "decomposition" or "weathering", from leaves to molecules or from minerals to elements; on the other side "composition", from mineral elements, organic molecules and water to biological structures (trees, animals…), neoformation clay, humic component, soil sub-units (peds). In aerated soils (terrestrial soils), thick organic horizons form on cold, acid and dry soils; in water saturated soils (semiterrestrial conditions), asphyxia delays biodegradation and the thickness of the organic horizons depends on the length of the saturation period.

2.2. Micro- , meso- , macroaggregates and mineral component

The humic component often takes the shape of soil aggregates, which are visible to the naked eye or with a magnifying hand lens and are classed in three types of structure, called micro-, meso- and macrostructures (Fig. 2). A level of structure finer than 1 mm cannot be detected by the naked eye (using a 10× magnifying lens, the limit is 0.1 mm). These very fine granular structures could be comprised of small arthropod or enchytraeid droppings (purely organic or mixed organic and mineral), layering or juxtaposed to mineral particles. Bound mineral particles visible within the humic component and strongly fixed in organo-mineral well-amalgamated aggregates (peds) are categorized as part of the humic component. On the contrary, mineral particles of different sizes, free or very weakly bound to the humic component and visible to the naked eye or with a 5–10× magnifying hand lens, are considered as other soil parts collectively named **mineral component**.